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CITATION:

Kojima, Masahiro ...[et al]. Formation of multiple ring-like wall in Nematic Liquid Crystal with focused laser beam. 物性研究 2006, 87(1): 166-167

ISSUE DATE:

2006-10-20

URL:

http://hdl.handle.net/2433/110594

Formation of multiple ring-like wall in Nematic Liquid Crystal with focused laser beam

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シュリーレン組織状のネマチック状態に、集光したYAGレーザーを照射した。その結果クロスニコル観察下で、レーザーの照射地点を中心として明暗が交互に現れる同心円状のパターンを生じる事を見いだした。この配向は一種のwall構造であり、隣接するリング半径の比は一定であることがわかった。

Liquid crystals have been applied to optical instruments widely. An achieving flexible and microscopic control of the liquid crystal is important for them. A method bestowing *Optical Fredericks transition*[1](OFZ) is an excellent one for such purpose. We reports the formation of multiple wall structure with nematic liquid crystal induced by local OFZ with a focused laser beam.

Nematic liquid crystal (5CB) with Schlieren texture whose thickness was less than 5 μm was irradiated by a focused cw Nd:YAG laser beam. On the spot, the director field was arranged so as to parallel to the incident laser beam.[2] When the spot is moved across the brush, a black ring pattern is formed.(fig.1) It was confirmed experimentally that the director of the black ring is perpendicular to the incident laser polarization direction and the pattern is a wall structure.(fig.2)

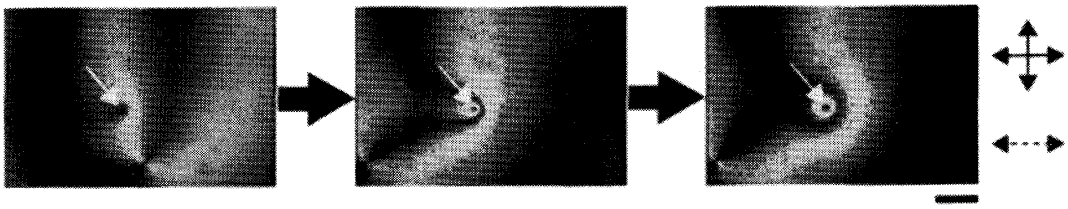

Figure 1: Snapshots of one fold ring formation. Scale bar is 10 μm. Solid arrow represents the direction of crossed Nicols. Dashed arrow represents the polarization direction of incident laser beam. The laser spot is travelling to right across the brush of which the director is perpendicular to the laser polarization.

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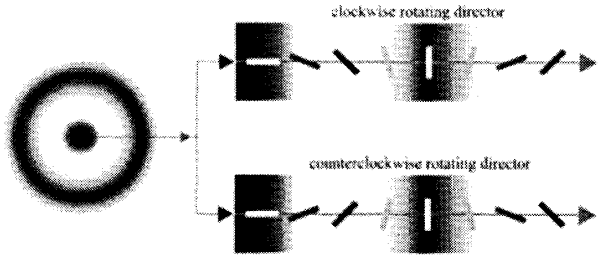

Figure 2: Schematic representation of ring like structure. The Structure is a wall and there exist two type of ring whose director rotate clockwise or counterclockwise along radial direction.

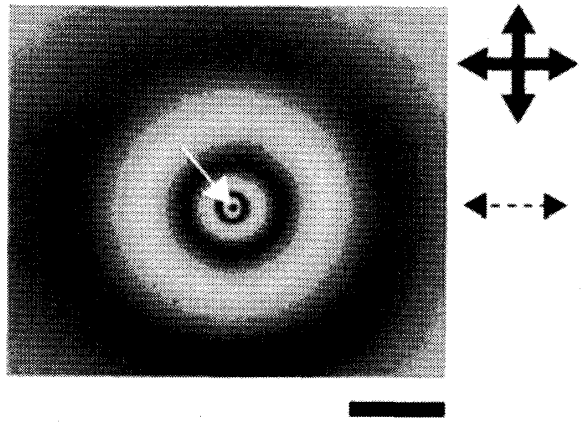

Figure 3: Triple ring-like wall structure. The laser spot is located the center of the circle. The symbols are identical to fig.1

Interestingly, it is found the target pattern is generated through such experimental procedure. Analysis of circular averaged intensity profile of fig.3, the ratio between radii of neighboring rings is constant. When the laser irradiation was stopped, the ring structure was annihilated immediately.

Let us discuss the interval between black and white rings. The elastic free energy F_d is given as[3]

$$F_d = \int \frac{1}{2} K(\partial_\alpha n_\beta)^2 d\mathbf{r} \tag{1}$$

Where K represents elastic constants with one constant approximation, α and β are x,y,z. Assuming that the directorn has circular symmetry, the director can be written as $\mathbf{n}$=(n_x, n_y, n_z)=($\cos\psi(r)$, $\sin\psi(r)$, 0). Where ψ represents the azimuth angle of director, r is the radius.

The $\psi(r)$ minimizing F_d is written as

$$\psi(r) = \frac{\psi_b}{\log r_b/r_c} \log r/r_c + \psi_c \tag{2}$$

Where the constants are the boundary condition that is approximated the effect of laser ($\psi(r_c) = \psi_c$) and bulk director field ($\psi(r_b) = \psi_b$). Eq.(2) give rise to the similarity low between radii of rings.

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